动 物 学 研 究 2007, Jun. 28(3): 325-328 CN 53-1040/Q ISSN 0254-5853
Zoological Research

A Record of the Invasive Golden Apple Snail *Pomacea canaliculata* (Lamarck 1819) at Black Dragon Spring, Dianchi Basin

DU Li-na[1,2], Jonathan Davies[1], CHEN Xiao-yong[1],
CUI Gui-hua[1], YANG Jun-xing[1,*]

(1. *Dept. of Systematic Zoology, Kunming Institute of Zoology, the Chinese Academy of Sciences, Kunming* 650223, *China*;
2. *Graduate School of the Chinese Academy of Sciences, Beijing* 100049, *China*)

Abstract: The golden apple snail *Pomacea canaliculata* (Lamarck 1819) was first recorded at Black Dragon Spring, Dianchi Basin, Baiyi Township, Songming County, Kunming City, Yunnan Province, China, in October 2004. The water from the spring flows into the Songhuaba Reservoir, the major drinking water resource for Kunming City, and part of the Dianchi Lake basin. This is the first record of this invasive snail in the Dianchi Lake Basin. *Pomacea canaliculata* originates from Central and South America, and in Asia the snail has spread through deliberate and accidental introductions to the Philippines, Vietnam, Thailand, Laos, Cambodia, Malaysia, Indonesia, Papua New Guinea, Korea, Japan and South China. It has become a major pest in rice-growing areas, resulting in huge damage to crops. Strict prevention and control measures have to be implemented to prevent the spread of the snail in Yunnan, together with public awareness campaigns to inform the public of the dangers of this invasive snail.

Key words: Golden apple snail; *Pomacea canaliculata*; Dianchi basin; Kunming; Yunnan; China

入侵生物金苹果螺在滇池流域的首次记录

杜丽娜[1,2], Jonathan Davies[1], 陈小勇[1], 崔桂华[1], 杨君兴[1,*]

(1. 中国科学院昆明动物研究所 系统动物学研究室, 云南 昆明 650223; 2. 中国科学院研究生院, 北京 100049)

摘要: 2004年10月, 中国科学院昆明动物研究所首次发现金苹果螺(*Pomacea canaliculata*)入侵重要的水源保护区嵩明白邑黑龙潭。金苹果螺起源于中南美洲, 在亚洲, 它通过有意或无意的传播而逐渐扩散到菲律宾、越南、泰国、老挝、柬埔寨、马来西亚、印尼、巴布几内亚、韩国、日本和中国的南部。金苹果螺已成为水稻产区的最大害虫, 给农业生产带来巨大的损失。为防止金苹果螺在云南扩散, 目前已经实施了严格的预防、控制措施, 同时开展了公众保护教育宣传活动。

关键词: 金苹果螺; 滇池; 昆明; 云南; 中国
中图分类号: Q 959.212 **文献标识码**: A **文章编号**: 0254-5853(2007)03-0325-04

The golden apple snail *Pomacea canaliculata* (Lamarck 1819) (Gastropoda, Prosobranchia, Mesogastropoda, Ampullariidae) is native to the temperate regions of South America, ranging up to the tropical areas of the Amazon basin. It may become invasive when introduced to a new region as factors controlling populations in its native region may be absent. These factors may be biological; including predation, disease, and competition; or environmental, for example temperature, altitude, and dissolved oxygen levels (Lach, 2000).

The snail seems to have been introduced to Taiwan in 1979-1980 as a food source for people; intro-

* Received date: 2007-01-11; Accepted date: 2007-02-11
* Corresponding author (通讯作者), E-mail: yangjx@mail.kiz.ac.cn
基金项目: 全球环境基金/世界银行(TF051795); 国家自然科学基金重大研究计划(90411002); 中国科学院知识创新工程重大项目(KSCS1-SW-13-4)

duction to the Philippines in 1982 was for similar reasons. However, in both cases, there was little market for the flesh of *P. canaliculata* and many snails were discarded into waterways from which they spread rapidly. The snail was introduced into Japan in the early 1980s as a food source, but also to control aquatic weeds. It is now mostly found in the southern parts of Japan, while in the north its range is limited by lower temperatures (Kenji, 2003).

The golden apple snail was also introduced to the Hawaiian Islands before 1989 as a food resource, and is now widely distributed in the islands (Lach et al, 2000). There seem to have been numerous introductions to Laos and Vietnam, now being found in 10 of the 17 provinces of Laos. In 1992, two farms for culturing the snail as human food were established in Vietnam, despite the experiences in the Philippines and Taiwan (Pallewatta et al, 2003).

It is likely that the snail was introduced into Guangdong, south-eastern China, in 1981 as a food source and started to spread from 1984 (Cai & Chen, 1990). More recently, it has been recorded in many provinces, such as Guangxi, Hainan, Fujian, Yunnan, Sichuan and Zhejiang (Yu et al, 2001), and Hong Kong (Liang & Ye, 1996). Despite the serious impacts that the snail had on rice crops in the Philippines and Japan, this does not seem to have discouraged deliberate introductions of the snails into other Asian countries. Chen (1991) previously reported the spread of the golden apple snail in Lufeng County, Yunnan Province. This record from the Black Dragon Spring is believed to be the first documented record from the Dianchi Basin.

There are several reasons for the snails' rapid spread in the wild. In the tropical areas to which it has been introduced, it can reach maturity in as little as two months and is highly fecund. In the Philippines, the reproductive period lasts from two months to three years and 1 000 to 1 200 eggs per month can be laid (PRRI, 2001), with an incubation period of 7 – 14 days. The snail is highly tolerant of polluted water, being able to survive in very low dissolved oxygen levels. Moreover, the snail can aestivate in the soil during periods of dry weather in seasonal wetlands. Its diet is broad, being a macrophage on plants with soft tissue. Indeed, in some areas, the reasons for its introduction were for weed control.

Based on climate data for China, Zhou et al (2003) speculated some southern provinces are the most threatened by the snail, where it can produce more than two generations per year. These provinces include Fujian, Guangdong, Guangxi, Hainan, Taiwan, parts of Jiangxi and parts of Yunnan. The bulk of the remaining areas in China were classified as threatened zones where the species can produce a single generation per year. Few colder areas in China were classified as lightly threatened zones, where the low temperature in winter will limit snail populations (Zhou, 2003).

1 Occurrence of the Snails at Black Dragon Spring

1.1 Identification

The presence of the snail was first recorded by the characteristic bright pink egg masses which are deposited on substrates above the water (native apple snails of the genus *Pila* all have white egg masses, whilst other species of the genus *Pomacea* have egg masses of different colours, www.applesnail.net). A sub-adult snail was recovered from the pool and was identified as *Pomacea canaliculata* by the characteristic deep umbilicus; a much swollen body whorl; deep sutures; large shell height (Carlsson et al, 2004); and tie pinkish-red egg masses as observed (Fig. 1). Egg masses of the snail have not yet been recorded elsewhere in the Dianchi Lake basin.

1.2 Materials

The Kunming Institute of Zoology (KIZ) Fish Collection Room holds 30 golden apple snail specimens from the Black Dragon Spring, preserved in 95% ethanol (CGH200401). The shell height is 40.15 – 70.21; body whorl height is 33.77 – 64.14; shell width is 31.76 – 58.90; apertural height is 26.82 – 50.00.

2 Impacts of the Snail

2.1 Direct impacts

Pomacea canaliculata has become a major pest in the countries to which it has been introduced. In Hawaii, the snail is the major pest of taro, *Colocasia esculenta* (Lach et al, 2000). In several countries, it is considered the most serious pest to rice production, resulting in huge economic losses in terms of crops and urgent implementation of control measures. In 1989, the Food and Agriculture Organization of the United Nations estimated that yield losses owing to this pest ranged from 1 – 40% in the rice fields in the Philippines (Dela, 2001). The total cost in 1990 to Philippine rice farmers due to loss

Fig. 1 An adult golden apple snail and an egg masses in Black Dragon Spring, Dianchi Basin (photographed by Chen XY)

of yields and costs associated with control was estimated as between USD 28 and 45 million (Ciruna et al, 2004).

It has also been implicated in the decline of native apple snails of the genus *Pila* (e.g. *Pila luzonica*) in the Philippines.

In addition to rice, in China the snail has been reported to feed on *Zizania latifolia*, *Trapa natans*, *Euryale ferox*, *Sagittaria sagittifolia*, *Nelumbo uncifera*, *Eleocharis dulcis* (Cai & Chen, 1996; Chen et al, 2003) and other aquatic macrophytes, such as *Alternanthera philoxeroides*, *Spirodela polyrhiza*, *Azolla imbricata*, *Pistia stratiotes*, *Eichhornia crassipes*, *Monochoria vaginalis* (Chen et al, 2003).

2.2 Potential impacts

The potential impact of this species in Yunnan could be devastating. Yunnan Province is considered to be an area of extraordinarily high biodiversity. There are more than 37 lakes of 1 km^2 or more on the Yunnan Plateau and many are unique ecosystems with endemic species of fishes, molluscs and crustaceans. Of the 432 fish species so far recorded in Yunnan, 67% are endemic to the province (Yang et al, 2004). The spread of the snail into these lakes and other wetland systems could be disastrous for the aquatic biodiversity of the province.

Of major concern to the Dianchi Lake basin is the snails' spread to rice fields and into the lake itself. Experience from rice growing countries such as the Philippines shows that economic losses due to infestation of rice fields can be huge. Moreover, the lake basin is the subject of an ongoing project aimed at restoring the biodiversity of the lake, which had been diminished by severe eutrophication and numerous introductions of fishes and water plants. One of the major aims of the Dianchi restoration project is the restoration of the clear water state and restoration of macrophyte beds. The snail poses a threat to the project in that, if it became established, it could easily destroy large areas of macrophyte beds, since many of the submerged macrophytes with soft tissue would be preferred food for the snail.

3 Preventative and Control Measures

When considering invasive species, prevention is much more desirable than control. With this in mind, every effort should be directed to preventing the entry of the invasive species into a region. If the invasive species has already entered, then it is vitally important to eradicate the pest as soon as possible from the limited areas in which it occurs. Once a pest species has become widespread, it is impossible to eradicate it totally; take for example the eradication programmes for other invasive species such as the water hyacinth. The snail has never been eradicated from any country to which it has been introduced despite control measures, and still remains a major pest.

4 Control Measures in Black Dragon Spring

The golden apple snail *Pomacea canaliculata* (Lamarck 1819) was first recorded at Black Dragon Spring in October 2004. After scientists from KIZ alerted the relevant local authorities to the presence of the snail, more than 400 people, including officials from more than 10 different management bureaus, local government and local people, responded quickly to the occurrence of the golden apple snail. From October 22nd to 28th 2004, the distribution of the golden apple snail in Fengzeyuan Botanical Garden and the area adjacent to the Black Dragon Spring, including Lengshui River, Muyang River, Qing Dragon Spring, Bai Dragon Spring and Songhuaba Reservoir, was investigated. The results of this investigation confirmed the snail only occured within Fengzeyuan, in approximately 3 335 m^2 of water areas.

The mean depth of water area in the Fengzeyuan area is 1.8 m and the storage capacity is about 50 000 m^3, the bottom is soft mud, in which the snails can bury themselves. In this region the snail has no known natural enemies and the environmental conditions are suitable for the growth and spread of the snail.

Form October 22nd to November 30th 2004, the local government organized local people to collect the golden apple snail and its egg masses with the aim of removing the snail totally from the area. Cumulatively, more than 400 snails and 900 egg masses were found and destroyed. Subsequently, from December 15th to 24th 2004, on recommendation from scientists at KIZ, local people drained the water from their fields and removed golden apple snails from the mud at the bottom. Because this area has high aquatic biodiversity, care was taken not to disturb native species of macrophytes, molluscs and fishes. As a final measure, calcium oxide (about 0.23 g/m^2) was spread over the bottom to kill juvenile snails.

A monitoring system to check on the occurrence of the snail has been established by KIZ. Up to the present time, four periods of monitoring in different seasons have been completed. In the course of the September 2005 monitoring, one snail was found at Fengzeyuan, but no egg masses were found. During the most recent monitoring period (December 2005 to January 2006), no snails or egg masses were found. The activities of removing the snail have been proved to be successful at Black Dragon Spring, and the control measures have been proved to be efficient within a small area such as Black Dragon Spring. Monitoring work on the snail will continue.

Acknowledgements: This work is funded by a GEF medium size project TF051795. We thank Dr. Li Jin-lu, Mr Pan Xiao-fu, Ms Ma Ying and Qian Xiao-hong, Kunming Institute of Zoology, for their help in many aspects. We thank all the staff of Kunming Water Management Bureau and other units who devoted in diminishing golden apple snails. Managers of Fengzeyuan Botanical Garden provided lots of conveniences to destroy the golden apple snail and help in the collecting and observation work.

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